Extensible Accelerator Language (XAL) Workshop
Facility for Rare Isotope Beams at Michigan State University

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Status of XAL at the European Spallation Source

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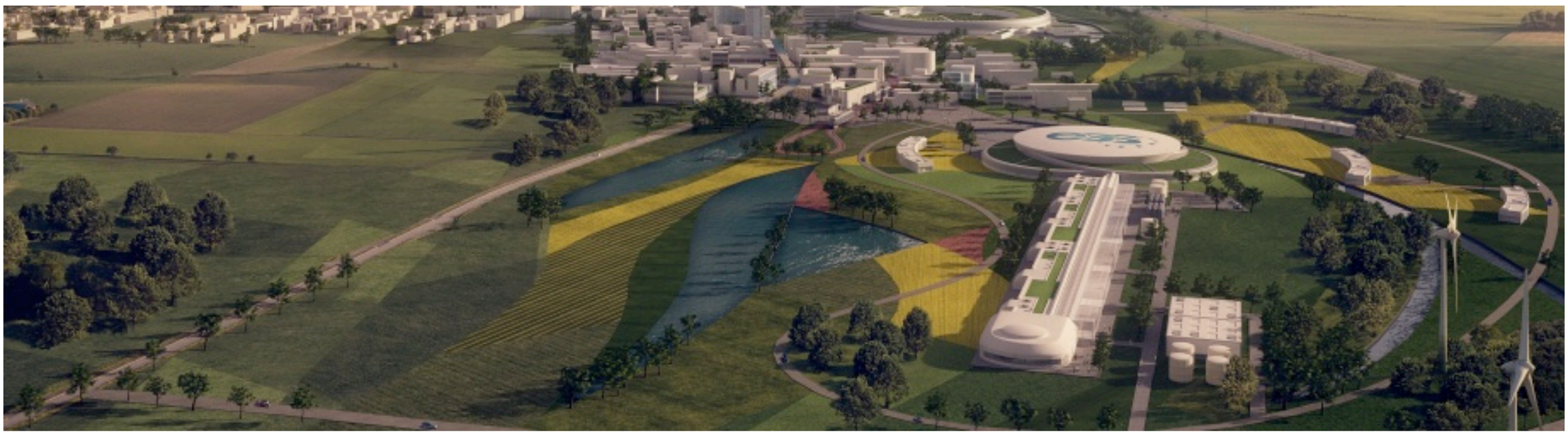


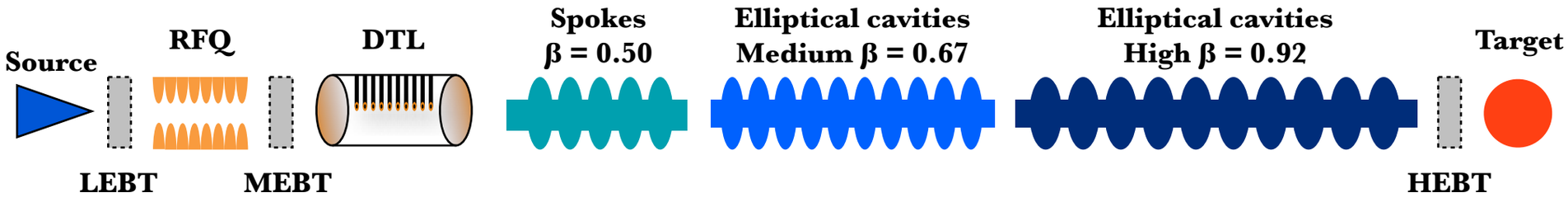
Key parameters for the ESS Proton Linac

	TDR 2012	
Power	5 MW	
Peak Power	125 MW	
Peak Current	50 mA	
Energy	2.5 GeV	
Pulse Length	2.86 mS	
Duty Cycle	4%	
Cryomodules	59	
Cavities	208	
Gradient	40 MV/m	
Frequency	352.21 MHz	

Key parameters for the ESS Proton Linac

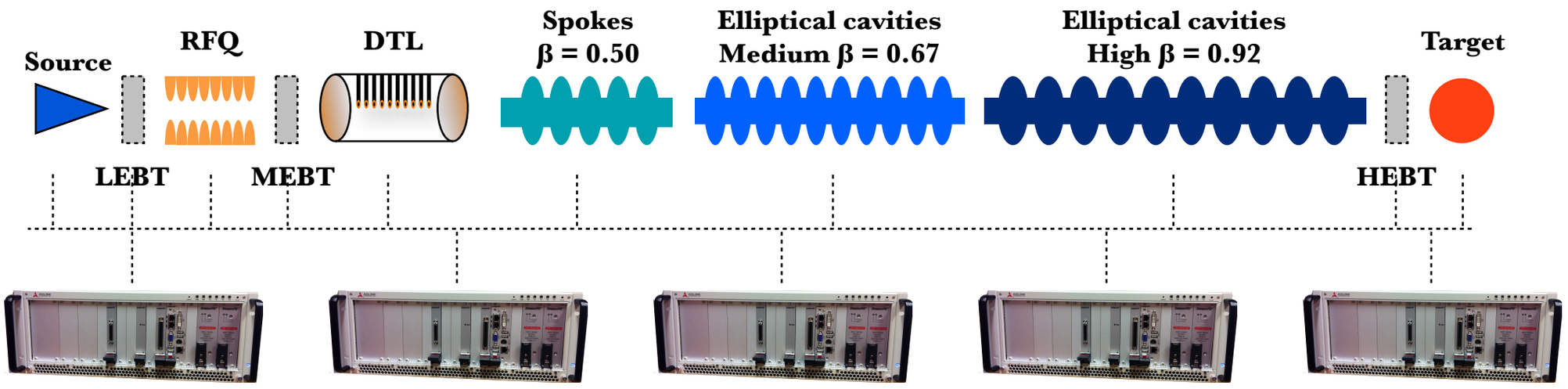
	TDR 2012	Commissioning
Power	5 MW	5 MW
Peak Power	125 MW	125 MW
Peak Current	50 mA	55 mA
Energy	2.5 GeV	2.275 GeV
Pulse Length	2.86 mS	2.86 mS
Duty Cycle	4%	4%
Cryomodules	59	50
Cavities	208	172
Gradient	40 MV/m	44 MV/m
Frequency	352.21 MHz	352.21 MHz

ESS layout



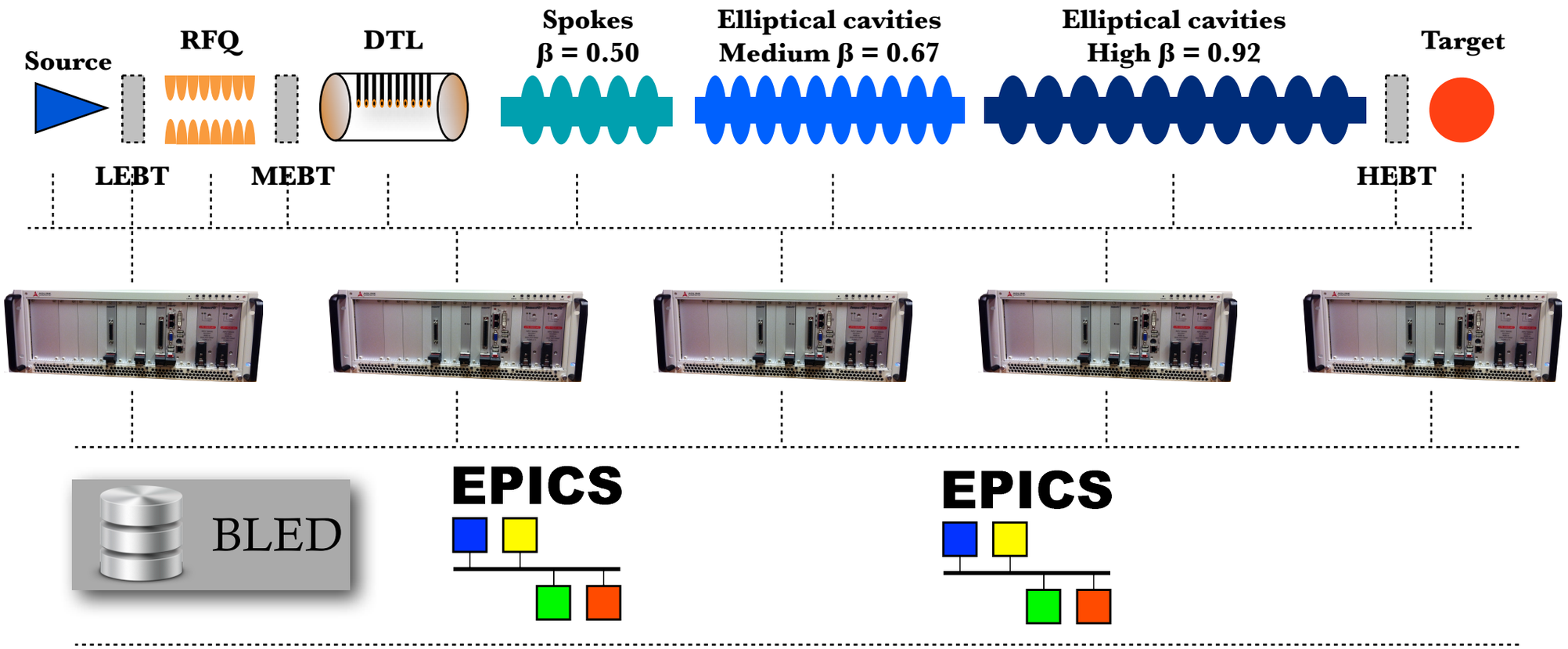
The Proton Linac

ESS layout



The Control Boxes

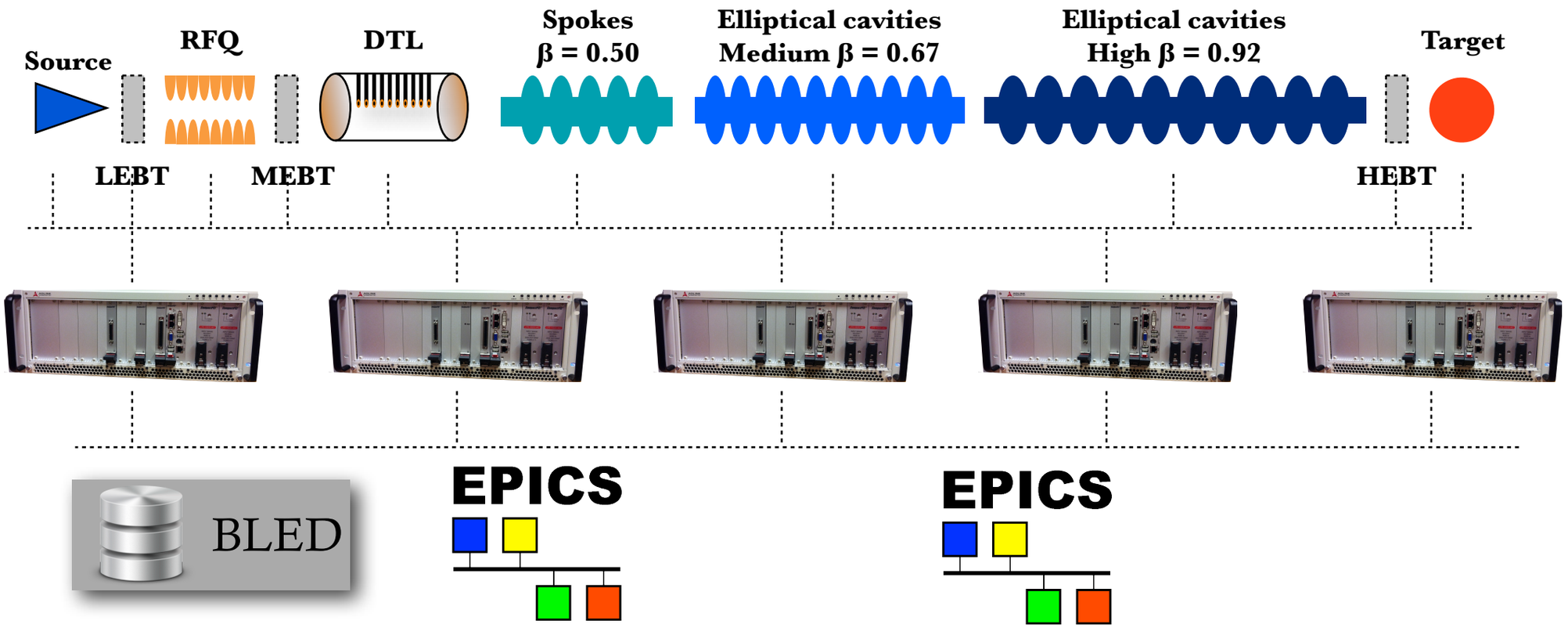
ESS layout

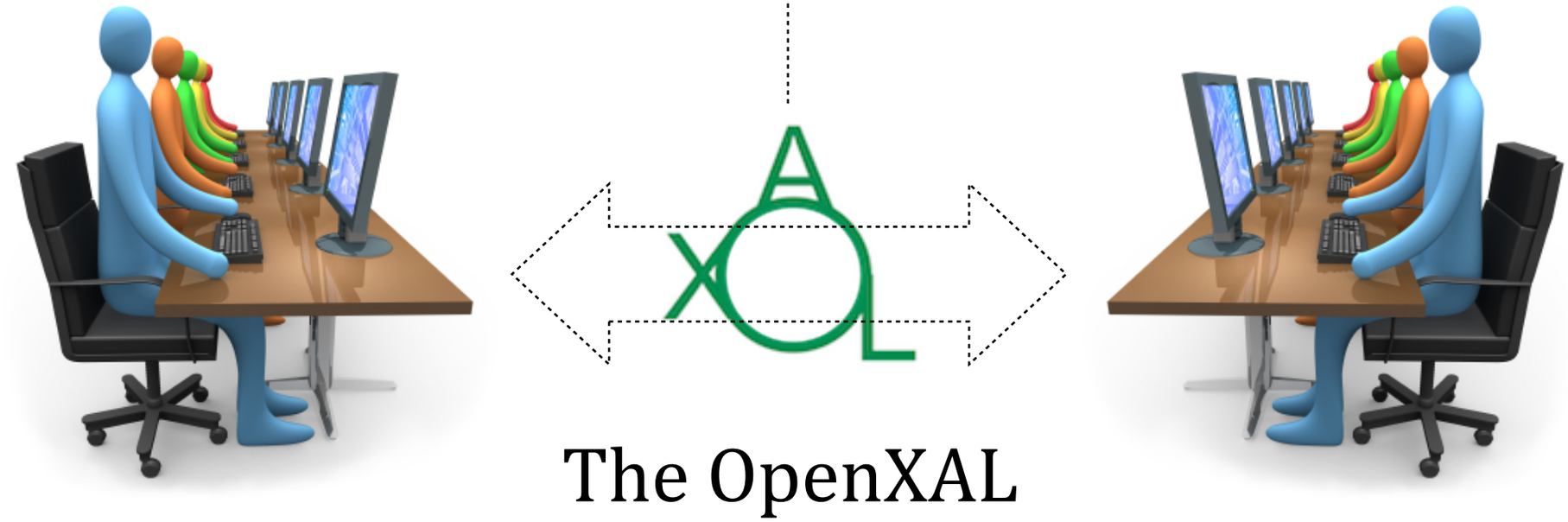


The Beam Line Elements Database

The EPICS abstraction layer

ESS layout





The OpenXAL

What is under development for XAL:

Physics

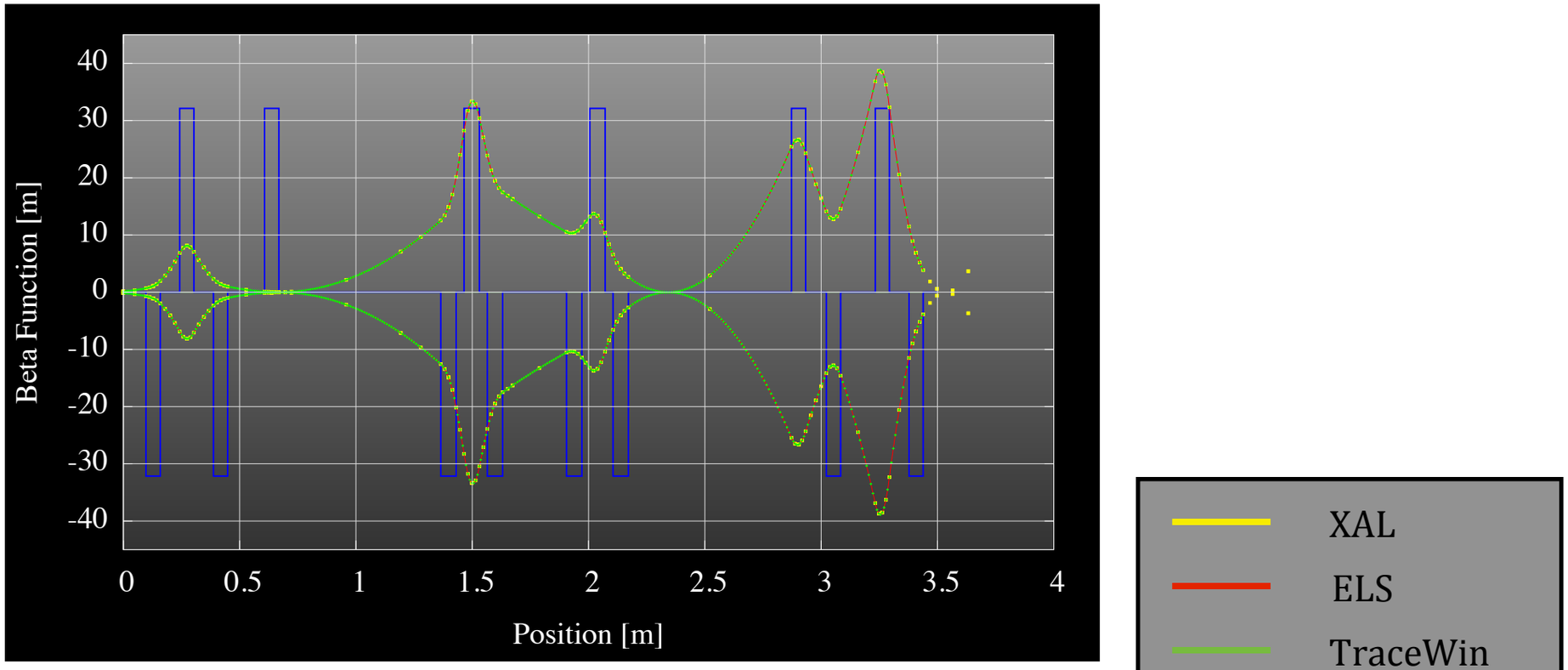
BLED connection

EPICS test

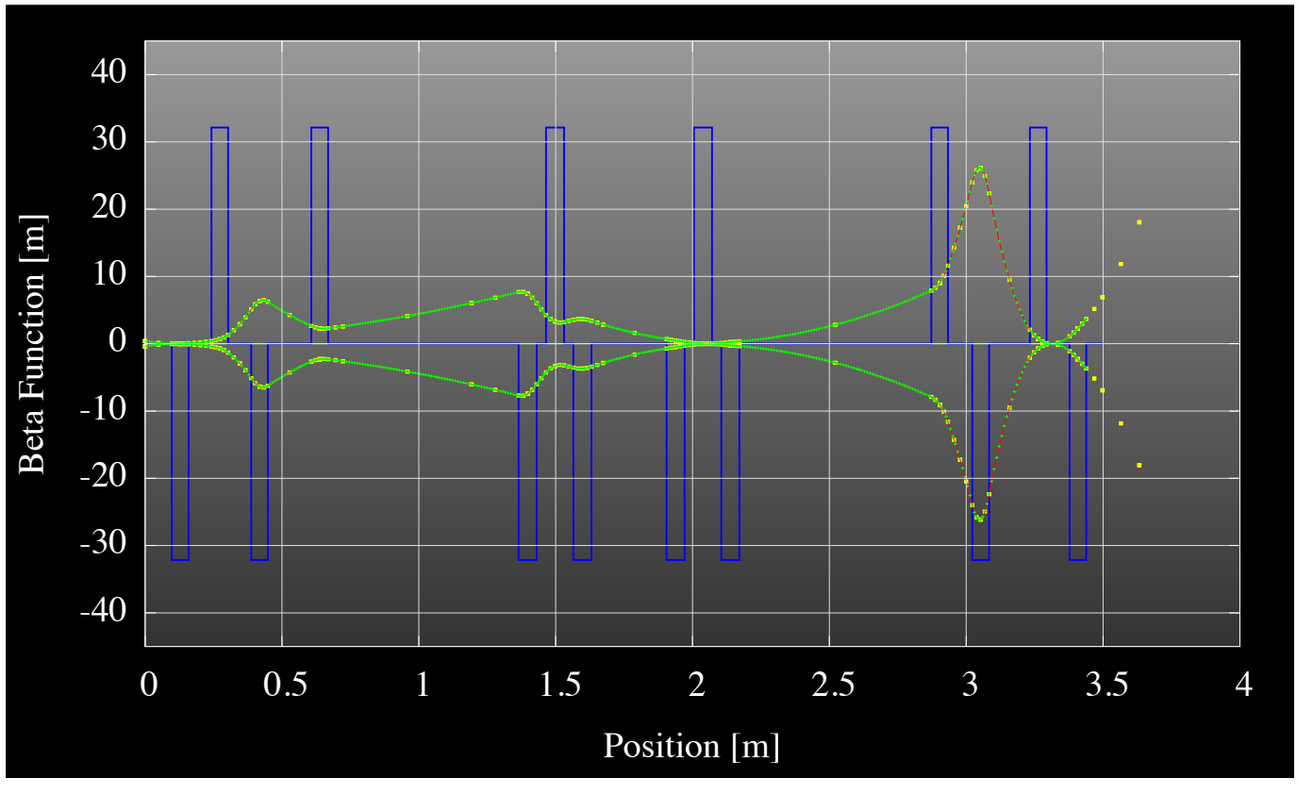
User Interface customization

Test of Online Model with zero current

Horizontal

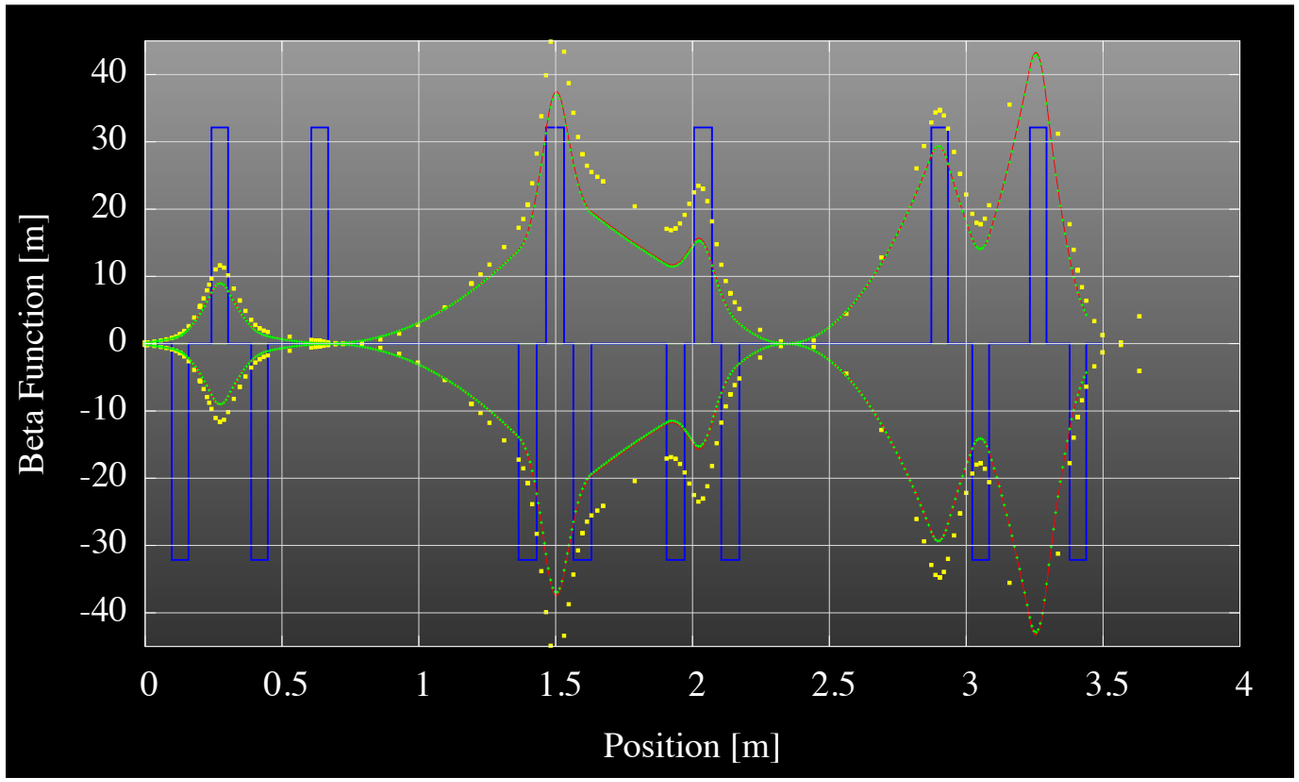


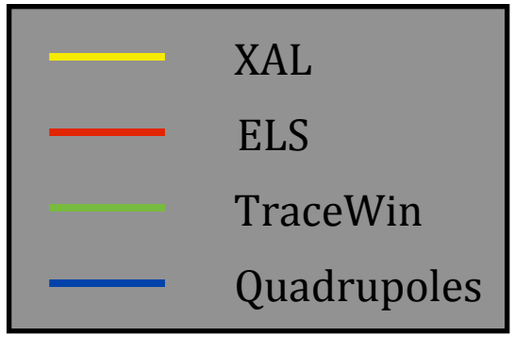
Vertical



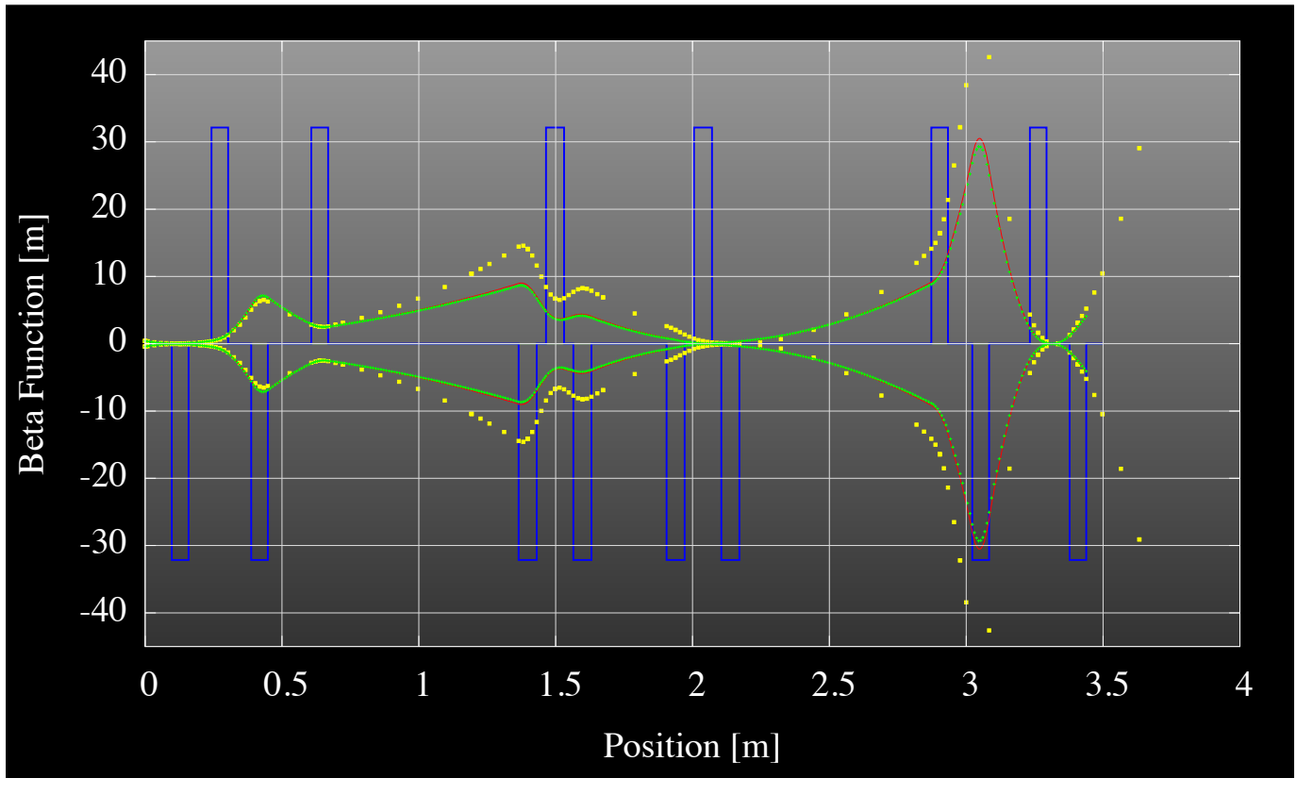
Test of Online Model increasing the current

Horizontal





Vertical



The common approximations such as elliptical or long bunches are not working properly for the space charge of the ESS beam:

$$U_{sc}(x,y,z) = \frac{eN}{4\sqrt{\pi^3}\epsilon_0\gamma^2}\int_0^\infty \frac{e^{-\frac{x^2}{2\sigma_x{}^2+t}-\frac{y^2}{2\sigma_y{}^2+t}-\frac{z^2}{2\sigma_z{}^2+t}}-1}{\sqrt{(2\sigma_x{}^2+t)(2\sigma_y{}^2+t)(2\sigma_z{}^2+t)}}dt$$

The ESS Linac Simulator (ELS) is using the adaptive algorithm (gaussian quadrature) to calculate the integral numerically.

Next actions:

RF cavities model

Matching system for the optics

Matching system for cavity failure

Update of algorithms for correction

Development of a multi-particle simulator

I did not mention here the actions to take for interfaces with BLED, EPICS and operators because my work is for the physics, but those topics are also under development at ESS.

Conclusions

ESS will use XAL, in the OpenXAL implementation, as interface for the control system.

The physics will be completely reviewed and adapted for the ESS proton linac.

XAL will be integrated in the ESS infrastructure developing the missing interfaces.

References

[1] E. Laface et al., “Space Charge and Cavity Modeling for the ESS Linac Simulator”, Submitted to IPAC 2013, Shanghai, China.

[2] E. Laface et al., “The ESS Linac Simulator: a first benchmark with TraceWin”, Submitted to IPAC 2013, Shanghai, China.

[3] E. Laface et al., “ESS End-to-End simulations: a comparison between IMPACT and MADX”, Proceedings of IPAC 2012, New Orleans, USA.

[4] R. Pissens et al., “QUADPACK, A Subroutine Package for Automatic Integration”, Berlin : Springer, 1983.

[5] P. Gonnet, “Increasing the Reliability of Adaptive Quadrature Using Explicit Interpolants”, ACM Trans. on Math. Soft. Vol. 33, Issue 3, Article 26 (2010).

[6] K.Y. Ng, “The transverse Space-Charge force in tri-gaussian distribution”, Fermilab-TM-2331-AD, 2007.